

“Social Laser”: Action Amplification by Stimulated Emission of Social Energy

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Abstract

The problem of the “explanation” of recent social explosions, especially in the Middle East, but also in Southern Europe and the USA, have been debated actively in the social and political literature. We can mention the contributions of P. Mason, F. Fukuyama, E. Schmidt and J. Cohen, I. Krastev to this debate. We point out that the diversity of opinions and conclusions is really amazing. At the moment, there is no consistent and commonly acceptable theory of these phenomena. We present a model of social explosions based on a novel approach for the description of social processes, namely, the quantum-like approach. Here quantum theory is treated simply as an operational formalism - without any direct relation to physics. We explore the quantum-like laser model to describe the possibility of Action Amplification by Stimulated Emission of Social Energy (ASE).

keywords Spontaneous and stimulated absorption and emission, social energy, Hamiltonian, discrete levels of energy, information excitations

1 Introduction

In recent years, we have seen the occurrence of a high level of social protests throughout the world, see, e.g., [1]:

“In the five short years between Occupy Wall Street and Vladimir Putin’s “Occupy Crimea,” we witnessed an explosion of protests all

around the world – the Arab Spring, Russian Winter, Turkish Summer, and the dismembering of Ukraine all were part of the protest moment. Each of these demonstrations – and many less monumental ones – was angry in its own way, but the protests are also a worldwide phenomenon.”

The structure and the causes of this wave of social activation was widely discussed in a series of publications in the social and political sciences, see, e.g., [1]-[5]. We point out that the diversity of opinions and conclusions is really amazing. At the moment, there is no consistent and commonly acceptable theory of these phenomena. In this paper we present a model of social explosions based on a novel approach used in the description of social processes, namely the quantum-like approach (see, e.g., the monographs [6]-[10] and the references therein). Here quantum theory is treated [6], [11] simply as an operational formalism - without any direct relation to physics. In this paper we explore the quantum-like laser model to describe mathematically the possibility of Action Amplification by Stimulated Emission of Social Energy (ASE). This is a model of a *social laser*.

In physics the discovery of the laser (light amplification by stimulated emission of radiation) was based on Einstein’s theory of *stimulated emission of radiation* [14]. However, it was only in the 1950’s that this theoretical study led to the creation of lasers (1964, the Nobel Prize went to Charles Hard Townes, Nicolay Gennadiyevich Basov, and Aleksandr Mikhailovich Prokhorov). Nowadays lasers found numerous applications and can be considered as one of the main technological outputs of quantum physics. It could be the case that the model of social laser describing ASE will also play an important role in the clarification and the description of social processes and social technologies. This is a pioneer study in this direction, but a variety of questions have to be clarified in more detail, see, e.g., section 7 for a discussion.

We remark that the modern presentation of quantum theory is based on the advanced mathematical formalism of operator theory in complex Hilbert space. However, as we know, the pioneering studies of Planck, Einstein, and Bohr were done before the creation of this mathematical machinery (by Heisenberg, Schrödinger, von Neumann, Dirac). These pioneering studies are known as “old quantum mechanics”. Surprisingly, the most important features of quantum mechanics leading to laser theory were obtained already in the old quantum mechanics: i.e. the discrete structure of energy levels for atoms and the quantum structure of electromagnetic radiation; spontaneous and stimulated emission and absorption. Here the discrete structure of energy levels of atoms was simply postulated by Bohr to derive the

stability of atoms. Then Einstein (motivated by Plank’s study on black body radiation) postulated the quantum structure of radiation. By using the quantum structures for atoms and radiation and thermodynamical considerations, he derived spontaneous and stimulated emissions and absorption which are fundamental in laser theory. In our social modeling, such an approach (i.e. a social-information version of old quantum mechanics) is preferable. Of course, like in the modern quantum formalism, spontaneous and stimulated radiation processes can be derived by using the modern theory of open quantum systems. However, the “old fashioned considerations” in the spirit of Bohr and Einstein clarify the basic assumptions leading to the functioning of the laser in a more intuitive and less formal way.

Nowadays the application of physical models outside of physics is well established and is a rapidly growing research activity. As a non-quantum example, we can mention *econophysics* [15], where the methods of classical statistical physics were successfully explored in economics and finance. See, e.g. [16]–[18] for quantum-like financial models. We also remark that recently the methods developed for non-Archimedean physical models which are widely used in string theory, cosmology, spin glasses, e.g. [19], [20], started to be actively applied in cognitive psychology e.g., [21], [22].

2 Elements of quantum theory explored in the ASE model

We plan to explore the quantum laser model to describe mathematically the possibility of *Action Amplification by Stimulated Emission of Social Energy* (ASE). We need not go deeply in the details of the quantum formalism to present its features which will be explored in this paper (see, e.g. [13] for a non-physicist friendly introduction to the quantum formalism). The main feature is *discreteness* (“quantumness”): the existence of stationary states of an atom corresponding to discrete levels of energy; then spontaneous and especially stimulated emissions of radiation by atoms. The basics of this theory were set out by Einstein [14].

Consider for simplicity the two level atom, it has the ground state ψ_0 and the excited state ψ_{ex} corresponding to the energy levels E_0 and E_1 , respectively. The main point is that the atom sufficiently sharply keeps one of those two states (at least ideally¹).

¹The real situation is essentially more complicated than it is typically described in textbooks on quantum mechanics. The most natural picture of the energy distribution is given by two Gaussian distributions sharply concentrated near their means, E_0 and E_1 .

The atom cannot be for ever in the state ψ_{ex} ; it has a tendency to emit a photon and fall to the ground state ψ_0 . This process is called *spontaneous emission of radiation*. The crucial characteristics of this process is that the energy of an emitted quantum (nowadays known as photon) equals the difference between the energies of levels:

$$\Delta E = E_1 - E_0. \quad (1)$$

Thus, the fixed type of atoms (characterized by their energy levels) can emit only photons of the fixed energy (the real situation is again more complex and we again have to proceed with the Gaussian distribution with mean value ΔE). This is the origin of spectral lines which can be observed experimentally (in reality these are Gaussian dimmed stripes).

However, different atoms in a population emit photons spontaneously in different directions and at random moments of time. Such a type of emission is characteristic for fluorescence and thermal emissions, see e.g., [23]. There is no *coherence* in emission. The same relation (1) plays a key role in the absorption of energy by atoms. An atom in the ground state can absorb only a photon of the energy ΔE . Photons with energies different from this quantity are ‘ignored’ by atoms of this type. Even in the absence of external radiation sources, the atom can neither be forever in the ground state: it jumps to the excited state (with some probability). This is a consequence of vacuum fluctuations or in the semiclassical models of the presence of the random background field. As was remarked, the atom reacts only to background photons of the energy ΔE .

This story was about spontaneous quantum processes. Their analogs will not play an essential role in the upcoming quantum-like social model. The main role will be played by stimulated emission and absorption. The inter-relation (1) gives the hint that if a population of atoms in the ground state is subjected to the radiation composed of photons of energy E_{ph} , then these atoms are able to absorb photons (with some probability) only if $E_{\text{ph}} = \Delta E$, where the latter is determined by (1). This is confirmed by quantum theory. This is *stimulated absorption*. In the same way, if a population of atoms in the excited state is subjected to the radiation composed of photons of energy E_{ph} , then these atoms emit photons (with some probability) if

$$E_{\text{ph}} = \Delta E.$$

Thus their dispersions are very small, but in reality they are nonzero. This remark is very important for social applications. Here reality is even further from the ideal model in physics.

Here a ‘stimulated atom’ does not absorb the ‘stimulating photon’. The atom relaxes to the ground state and two photons are in flight. This is *stimulated emission*. Thus, if an external photon with the energy $E_{\text{ph}} = \Delta E$ stimulates emission from some atom then it results in two photons of this energy. These two photons can stimulate emission from two atoms, resulting in four photons and so on. There the number of emitted photons increases exponentially.

The main distinguishing feature of this process which will play the fundamental role in the upcoming social modeling is that this emission (in opposition to spontaneous emission) generates the coherent beam of photons. The emitted photon is a copy of the photon which had stimulated emission. In particular, an atom emits a photon in the same direction as the light passing by. It provides a beam which is sharply concentrated in one fixed direction.

The coherence in a beam is not reduced to the spatial dimension: there can be plenty of synchronization in this beam. In our social modelling applications, we explore a possibility of such synchronizations. In the wave picture, the main occurrence of coherence resides in the *constructive and destructive interference*. Thus, the contributions of different photons can be amplified (and very strongly) or canceled (practically completely).

We finalize the discussion with the following list of quantum features:

1. Discrete levels of energy (for atoms and fields)
2. Bose-Einstein statistics of field quanta
3. Spontaneous emission
4. Stimulated absorption and emission
5. Coherent emission

3 Laser: light amplification by stimulated emission of radiation

The quantum effects of stimulated emission and absorption were established at the very beginning of quantum theory. However, only in the 1950’s were these effects realized in devices which are known nowadays as lasers. Schematically, the laser has a simple structure. The *gain medium* is a population of atoms (with an identical structure of energy levels)² which are excited by an external source of energy (pump). A pump based on a light source, or an electrical field supplies energy for

²Impurities would contribute to decoherence of the emitted beam.

atoms to absorb and be transformed into their excited states. Initially the majority of atoms in a population are in the ground state, the minimum energy state. When the number of particles in the excited state exceeds the number of particles in the ground state (as the result of the pump), it is said that *population inversion* is achieved. Then, for such population, *the amount of stimulated emission due to light that passes through is larger than the amount of absorption*.

Hence the light sent to such population will be *amplified* and the output will be coherent. This process has only two components:

- The pumping of energy to the gain medium, the atom population, to approach population inversion
- Stimulated emission of light

For some types of lasers, this two component process leads to the required amplification of light. And, for a moment, we restrict consideration to such lasers. In other types of lasers, the beam obtained as the result of stimulated emission is reflected from a mirror ($M1$) and send back through the gain medium, again amplified, and reflected from another mirror ($M2$), and so on. This amplification process can be repeated a few times generating higher amplification. However, as we pointed out, we proceed with the simplest type of lasers combining pumping with stimulated emission.

We also remark that two level atoms are not the best gain medium: atoms with a more complex level structure are used to produce better lasers. In the quantum optics framework, the population inversion can be approached only in a gain medium consisting of atoms having at least three levels and with a special structure of transition probabilities. For our further studies, it is important to remark that this is a consequence of coincidence of Einstein's B -coefficients describing the transition probabilities for stimulated absorption and emission, $B_{12} = B_{21}$. This coincidence is questionable in our quantum-like social studies. The field of social information excitations is a boson field, i.e. its quanta satisfy the Bose-Einstein statistics. However, there are no reasons to identify its mathematical structure precisely with the electromagnetic field (although the latter is convenient as giving the simplest model). Moreover, the standard derivation of coincidence of Einstein's B -coefficients (for the quantum electromagnetic field) is based on the assumption of approaching the thermodynamical equilibrium and the probability distribution for the field's energy described by the Planck law for black-body radiation. Even the approachability of such an equilibrium in social modeling can be questioned. Thus, in principle the social analogs of lasers based on two level systems are possible. However, we ignore these technicalities (which are in

fact very important even in the social engineering of ASE): we want to present just the basic scheme of amplification of coherent social information excitations.

That is all: we need nothing more from quantum physics. We shall now establish the correspondence between elements of the quantum physical and the quantum-like social model.

4 From “it from bit” to the quantum-like formalization of social information excitations

In modern physics the purely information interpretation of physical laws plays the important role apotheosized in Wheeler’s “it from bit” [24]. D. Chalmers [25] summarised Wheeler’s views as follows:

“Wheeler (1990) has suggested that information is fundamental to the physics of the universe. According to this “it from bit” doctrine, the laws of physics can be cast in terms of information, postulating different states that give rise to different effects without actually saying what those states are. It is only their position in an information space that counts.”

The information approach in physics is very supportive to applications of physical formalisms to the cognitive and social sciences. In particular, Chalmers continued:

“If so, then information is a natural candidate to also play a role in a fundamental theory of consciousness. We are led to a conception of the world on which information is truly fundamental, and on which it has two basic aspects, corresponding to the physical and the phenomenal features of the world.”

Recently the information approach to physics culminated in a variety of information interpretations of quantum theory. We mention just a few of them:

1. Zeilinger-Brukner: quantum state as a presentation of (private) information about possible results of measurements on a system [26]-[28];
2. Fuchs (in cooperation with Mermin, Caves and Schack), QBism, Quantum Bayesianism: quantum state as presentation of subjective probabilities about possible results of measurements on a system [29]- [31];
3. d’Ariano (in cooperation with Chiribella and Perinotti): derivation of the quantum formalism from a set of information-theoretical postulates [32]-[34].

In the information approach, quantum mechanics is not about a ‘quantum world’, but about our (observers) predictions on the possible results of measurements which can be performed on micro-systems. This viewpoint is close to the original views of Bohr and especially Pauli, see [35]. Of course, the purely informational interpretation of quantum mechanics and physics in general does not deny reality. For example, Bohr never denied the existence of atoms as material entities. However, only the state structure of atoms is described by the quantum formalism (whether a deeper description is possible is still the subject of stormy debates in quantum foundations). From this viewpoint, any entity whose state structure can be mapped onto the state structure of atoms can be in principle described by the same quantum formalism. By using the information interpretation of quantum field theory we can view quantum fields as *quantized information fields*. Their quanta, excitations of quantum fields, can be interpreted as quanta of information. In particular, the quantum electromagnetic field can be treated as a special information field with quanta known as photons. We remark that the spatial wave-function of a photon is not well defined. Therefore it cannot be interpreted as a localized physical particle and it cannot be interpreted as a physical wave. Thus the most consistent way is to treat it as a quantum of information, given by the momentum and polarization vectors.

We now explore the information viewpoint to physical formalisms and borrow them for our social modeling. Individuals are mapped to atoms: we can speak about “*social atoms*”, *s*-atoms. Human populations, societies, are mapped to atom populations. In particular, in our model human societies play the role of gain mediums. The information exchange between *s*-atoms is formally modeled with the aid of a quantized information field. Its quanta are interpreted as social information excitations. It is natural to model the information field as a boson field (see energy-considerations below). As was remarked above, the simplest (from the mathematical viewpoint) boson field is the electromagnetic field. Therefore, we proceed with the information field (transmitting the information to and from *s*-atoms) which is described as the quantum electromagnetic field (this is just borrowing from physics the concrete model of information exchange, nothing more). Thus, the quanta of information carrying social excitations are modeled as social analogs of photons, *s*-photons (see section 7.1 for further discussions).

One of the basic assumptions of our model is that the states of *s*-atoms and photons can be characterized by a quantity which can be transferred into social activity (‘work’) of individuals or groups of individuals. We call it the *social energy*. As well as in physics,

the social energy is a primary quantity which cannot be derived from more elementary ones. Again, as in physics, this is simply a tool for the quantitative characterization of possible activities of individuals³. On the operational level, in quantum-like models the social energy is represented by an operator (Hamiltonian) generating the dynamics of a mental state, similarly to quantum mechanics. This quantity was successfully used in quantum-like financial models representing the energy of expectations of traders [9]. We remark that the value of the social energy does not determine the concrete structure of an excitation and a possible action induced by it (in the same way as in physics the value of energy of an excited state does not determine the direction in which the photon can be emitted). We understood well that the problem of the interpretation of the social energy has to be analyzed in more detail. We cannot do this in the present paper, but see section 7.2 for a brief comparison of the notions of the quantum and social energies.

The next fundamental assumption is that, for some societies, *the levels of the social energy for s -atoms are quantized*, sharply concentrated. For example, the ground state (the minimal social energy in this society) and the state of a social excitement. In the simplest model, as in the previous sections, we characterize these states by just two numbers E_0 and E_1 . In reality they can be collections of parameters characterizing states. We remark that the sharpness of the levels of social energy is dimmed: it is of the Gaussian type, cfr. section 2. We also assume that the information fields are quantized.

We now motivate that the basic energy absorption-emission relation (1) holds even for social energy. We proceed under the assumption of the discreteness of energy levels of individuals (in a population under study) and the quantization of information fields, namely, the transmission of social excitations by quanta of information, see section 7.1 for a foundational discussion. Since a few quanta of the information field (realized, e.g. as TV-communications) can carry the same social energy, their distributions have to obey the laws of Bose-Einstein statistics, i.e. information fields are boson fields. And, as a model, we select the simplest of them, namely, the quantum electromagnetic field.

In our framework a social analog of the following property of the physical photon is crucial : an atom cannot ‘eat’ a part of photon: it either eats the whole portion of energy carried by the photon or

³In physics a better understanding of the features of energy is approached through the description of mutual transformations of various types of energy. In thermodynamical studies, see [36], [37] for a similar attempt for the ‘information energy’ – the energy of expectations of traders of the financial market.

simply ignores this portion, if its energy is too small or too large to match with the energy structure of the atom. This property matches well with the absorption of information by humans: an individual typically does not try to split a communication, e.g. in TV-news, into pieces and takes into account some concrete piece of it. The whole communication is either ‘eaten’ or not.

If the s -atom has only one excited state, then automatically it can ‘eat’ only a communication carrying the social energy given by the social analog of the formula (1). Thus the validity of this formula in social processes is a consequence of the discreteness of the energy levels of the structured human media: the discreteness of energy carried by information communications; the tendency of humans to absorb communications as indivisible entities, quanta. And the discreteness implies that only information quanta of concrete energy can be absorbed by individuals⁴.

We presented the model of absorption of social radiation. Now if the E_1 -excited individual relaxes, approaching the ground state, she/he can emit only a social information excitation potentially leading to a social action, having the energy given by (1), since she/he could not relax to some level in between E_0 and E_1 . This emission can be spontaneous: an individual cannot be forever in the excited state: she/he relaxes to the ground state. Spontaneous as in physics means a-causal. She/he relaxes without any definite cause for falling into the ground state. It is impossible to predict when and in which way, a human relaxes from the state of excitement and ‘emits a social information excitation’. The latter may lead to a social action of the corresponding social energy. However, even in physics many photons disappear in a medium and noisy background radiation, in the same way as many social information excitations, which are excitations in the information space, do not lead to real actions. They disappear in a noisy information background. Such spontaneous mental relaxations definitely match with human behavior.

However, we are more interested in a social analog of the stimulated emission. This is the most complicated part of the model. In quantum physics, to derive the stimulated emission one has to explore the wave picture of the photon and the coupling between the photon’s frequency and energy. For excitations of a social quantum-like

⁴Heuristically this picture is very natural. Humans suppress, e.g. the information communications carrying the energy which is essentially higher than the level of socially acceptable excitation in a population with structured social energy. We all ignore the communication that, since the 1970’s around 50% of living species disappeared from Earth. This excitation carries a too high energy. An individual in an energy structured population is not ready to process such an excitation (at least not consciously).

field, the proper frequency interpretation is not so straightforward as it is for photons (see section 7.4 for a discussion). For a moment, we discuss the stimulated emission of social information excitations from the heuristic viewpoint (cfr. with Einstein's derivation in the pioneering work [14]). An s -atom A in the excited state interacts with an information field. The latter is quantized, it is composed of excitations of various energies and directed to various social actions. The stimulated emission means that A ignores all information quanta, communications, having the energy different from $\Delta E = E_1 - E_0$ (again in reality we have a Gaussian distribution with the mean value ΔE). However, if a communication has the same energy⁵ as ΔE then the probability of A 's relaxation increases essentially and if A relaxes, then her/his possible action is identical to the potential action carried by the stimulating excitation⁶.

5 The structuring of social energy

The primary assumption for the possibility of ASE is the discrete structure of the social energy for individuals in some human societies. In a society where individuals have a continuous spectrum of the social energy, ASE is impossible.

In any society an individual can become mentally excited to some degree (with some probability). For example, consider the various degrees of states of a social protest: from carrying an opposition mentality to participating in demonstrations, barricades and revolutions. If a society is clustered into a variety of groups of various degrees of excitement, this is not the case in our modeling. Consider a society where for example one individual is prepared just for demonstration and another individual wants only to express oppositional views in front of his wife or friend, whilst another individual is ready to go to protest against the system, but in a peaceful way. There may be also groups planning actions of different degrees of violence. Such type of society is difficult to subject to a stimulated *coherent excitation*.

The degree of excitement has to be homogeneous, i.e. it is structured in such a way that it is 'natural' to belong to the same level of excitement or to be in the ground state (we remind the reader that the simplest two level model is under consideration).

⁵For example, in modern Western society, this is a web-call for an anti-globalist demonstration and not a call for a military operation against the government.

⁶The latter is natural: by accepting the communication about the anti-globalist demonstration one will go to such a demonstration and not to a demonstration against the discrimination of women, even if both carry the social energy of the same degree.

In modern Western society it is natural and well accepted to have social excitement at a concrete level: e.g. to demonstrate against cuts to education or social needs (the energy level E_1), but not to be excited about a revolution against the system. We remind ourselves, that we do not speak about sharp levels, but about Gaussian distributions concentrated around the levels. The number of people with social energy $E \gg E_1$ is negligibly small. There are practically no people who are ready to struggle to destroy the system. At the same time, not so many people have the energy distributed in the gap $\Delta E = E_1 - E_0$. People are either ‘socially active’, of the same E_1 -level or simply socially passive, of the same E_0 -level. This society is well structured and it can serve as the basis for ASE (please see section 8).

At the beginning of the 20th century, Russian society was well structured, but with essentially higher energy E_1 . It was very fashionable (even for intellectuals and a part of bourgeoisie) to be in the state of revolutionary excitement. People were not interested in social activities with energies distributed in the gap $\Delta E = E_1 - E_0$. Of course, such groups existed, as, e.g. the followers of Leo Tolstoy, the Tolstoyan movement, but they were negligibly small compare to the total socially active population. From the quantum viewpoint these are just impurities in the gain medium.

The energy structure of a society is determined by the social context which combines cultural, historical, economic, financial, political and even weather conditions⁷. Since social energy is an informational quantity, the aforementioned components of context are also of a pure informational nature. Roughly speaking, it is not the real political situation, but its representation by various sources of information which is important. Nowadays, the mass-media and internet are the main sources of discretization of social energy. An individual feels comfortable to belong either to the ‘socially active part of society’ (the same level E_1) or to live an ‘ordinary life’. Internet-communities play an important role in the energy structuring of the human gain medium and in the homogenization of the excitation strength. However, in this paper we have no possibility for a detailed analysis of this psychological phenomenon.

⁷In general the notion of context plays a crucial role to motivate applications of the operational quantum formalism to cognition, psychology and social science. Cognition (both on individual and collective levels) is intrinsically contextual, and so are quantum phenomena. Here we have no possibility to discuss the issue of contextuality in more detail, see, e.g., [6], [39]–[42].

6 Action Amplification by Stimulated Emission of Social Energy

The social laser is based on the human gain medium, a population with a discrete structure of levels of social energy. We proceed with the simplest model: a population with the two level structure⁸. Typically, a majority of people are being in the ground state, the state of the minimal social energy. However, by pumping social energy into a population its inversion can be approached, so a majority of people will be excited. In physics, pumping typically is of the short pulse-form. A strong pulse delivers a lot of energy to the gain medium, but it has to be short otherwise it may destroy the gain medium. The social energy pumping has to have the similar structure: a short pulse of news. When population inversion is achieved, this is the time to start stimulated emission. The human gain medium is exposed to the flow of coherent news, having the energy given by (1). Stimulated emission starts and it induces a cascade of coherent social information excitations (of the exponentially increasing strength) leading to a coherent action of this population, e.g. in the form of a social protest. The latter can imply the realization of huge social energy.

7 Interpretational issues

7.1 Quantization of human excitations

The main interpretation problem in using the photon metaphor for the mathematical modeling of human excitations is that even in quantum physics the notion of photon is the subject of intense debate (since the invention of the light-quantum by Einstein in 1905). Roughly speaking, the following problem has been debated during the last one hundred years: does an electromagnetic field quantize in a vacuum? Does a photon ‘exist’ in the absence of matter? Is the notion of photon meaningful only for the description of the process of interaction of the electromagnetic field with matter? Modern quantum physics is based on Einstein’s viewpoint: yes, a photon exists even in the absence of matter⁹. In our framework the question of the ‘existence

⁸In reality, as in laser physics, more complex structures of energy levels have to be explored. We shall consider such models in upcoming publications.

⁹However, we remark that some fathers of quantum mechanics, e.g. Lamb and Lande disagreed with Einstein (and Lamb died not long ago, he preserved his viewpoint in the light of all the successes of quantum mechanics), see [43] for details and modern attempts to proceed in the Lamb-Lande direction. The main argument for the interpretation of

of mental photons' can be formulated as follows: can human actions (or more precisely excitations to perform actions) be treated independently from individuals? Do human excitations live their own life? This is an interesting philosophical and methodological question. However, for the moment we ignore it completely (so as to avoid being involved in a debate similar to the debate on photon existence).

7.2 Social versus quantum energy

Now we briefly discuss and compare the notions of energy in quantum physics and quantum-like sociology. The reader might feel that the notion of social energy invented in section 4 is fuzzy and less intuitive than the notion of physical energy. He/she is correct with respect to the comparison of *classical physical energy* with social energy. However, the notion of energy in quantum mechanics is less intuitive than in classical physics. One could not simply assign a concrete value of energy to a quantum system, if it is not in a stationary state (e.g. an atom can be in a superposition of the ground and excited states, i.e. its energy is neither E_0 nor E_1 and at the same time both E_0 and E_1). The concrete value of energy is determined only as the result of its realization in the process of detection. In the same way in general the individual's state cannot be characterized by the fixed value of the social energy. Stationary states (at least different from the ground state, the state of the minimum of social energy) are not stable.

7.3 Social versus photon's momentum and polarization

The photon's state can be characterized by the momentum vector p and polarization vector s . The first one represents operationally the direction of propagation of the photon and the second represents a special internal degree of freedom of the photon. By using the same mathematical model we equip the s -photon with a (social) momentum and polarization. The first specifies the general 'direction' of a

a photon as simply an excitation, an action transmitter, is that the presence of photons can be detected only with the aid of material particles, in the process of detection. We can detect only their actions and typically the act of detection (the action's realization) leads to the photon destruction. It is worse to mention that the position representation of photons (representation in space-time) is not well-posed, the wave function of photon cannot be properly defined (although the last hundred years were characterized by numerous attempts to proceed in this direction). As a result of this problem, the photon is typically treated not really as a particle, similar to e.g. an electron, but as an *excitation* of the quantum field.

possible social action, e.g. anti-war activity, anti-globalism etc...The second represents concrete characteristics of the social excitation ‘directed’ by the momentum p . For example, k = ‘anti-war in Vietnam activity’, s = ‘March 25-26 (1966). Days of International Protest. Organized by the National Coordinating Committee to End the War in Vietnam.’ In quantum mechanics the polarization space has the dimension two. However, in principle we are not rigidly coupled to the photon model. For us, the photon is just one of the possible transmitters of action. The quantum theory of *gauge fields* provides us with plenty of mathematical models with more complex spaces of internal degrees of freedom.

In previous considerations we discussed only the interpretation of the direction encoded in the momentum, i.e., given by the normalized vector $\frac{p}{|p|}$. In physics its length is proportional to the photon energy. We can proceed in the same way (here it will be the definition of the magnitude of the social momentum).

7.4 Frequency interpretation

By interpreting the s -photon as a ‘quantum of possible action’ and assuming (by extending Einstein’s idea to the social domain) that the social energy is quantized even in the absence of interaction with concrete individuals, we can treat the social information space as filled by quanta of possible actions. Such s -photons are purely information entities. How can we characterize their energy (before its realization)? It seems that, for such a purely information quantity, its energy can be characterized by the *frequency* ν of its appearance in the information space (e.g. in TV-news, in newspapers and Internet). Thus, it is natural to couple the frequency of communications with the energy of a social quantum of excitation. What is the form of the frequency-energy relation? In quantum physics this relation is given by the Einstein formula:

$$E_{\text{ph}} = h\nu, \quad (2)$$

where h is the Planck constant. This is the simplest possible law, the linear one. One may try to keep this relation even in social modeling. In quantum physics (2) is treated as the explicit relation. In our study we can treat its social analog as just a linear approximation of a more complex nonlinear law. The presence of the fixed constant h in (2) is a delicate problem. We definitely cannot expect that a kind of ‘social Planck constant’ exists. It is more natural to expect that different types of social excitations are characterized by coefficients of proportionality of different magnitudes (cfr. for discussions on a financial analog of the elementary quantum of action, see [6], [9]).

The reader has already noticed that in the model of the social laser we proceeded without the frequency interpretation for the s -photon. It is clear why. The frequency is coupled to wave features of the photon. In physics the basic law of radiation is given by the Planck-Einstein formula:

$$\Delta E = E_1 - E_0 = h\nu. \quad (3)$$

We split it: only its first part, see (1), was in play. Now we discuss its second part, see (2).

Of course, even a physical photon (quantum of the electromagnetic field) cannot be simply imagined as a classical wave propagating in space modeled as \mathbb{R}^3 . However, such a heuristic picture has at least some illustrative power. For the s -photon, \mathbb{R}^3 is used to encode the ‘directions’ of action (this is simply a linear space representation of mental states which is widely used in cognitive science, psychology and the social and political sciences, e.g. [44].) Even heuristically it is difficult to operate with waves in this action-space. However, we should not forget that operationally the only exhibition of (physical) photon wave features is the interference of probabilities of detections. Similar interference features of mental entities have been studied sufficiently well [6], [7].

8 Concluding remarks

By exploring the quantum principles of laser functioning we formulated the corresponding principles of functioning of the ‘social laser’, generating Action Amplification by Stimulated Emission of Social Energy (ASE). The analogs of fundamental quantum principles leading to the possibility of the creation of social lasers can be formulated as follows:

- the social energy of individuals in some human populations, ‘gain mediums’, can be structured in discrete levels;
- a human gain medium can absorb and emit information excitations only with energies equal to the difference between energies of discrete levels, see (1);
- an information excitation having the energy matching the discrete levels of an individual, stimulates emission of an excitation in the state which is identical to the state of the stimulating excitation.

The structure of the social laser is similar to the structure of the physical one:

- a human gain medium;
- pumping of social energy to it – to approach population inversion;
- stimulating of emission from the gain medium.

In this paper we presented a general quantum-like model of ASE. We do not try to couple it to concrete social protests, including the recent ones mentioned in the introduction. This is not our task. The descriptions of special human gain mediums, the structures of their discrete levels of social energy and the machinery of energy pumping and stimulated emission can be done by experts in the social and political sciences.

Finally we remark that the expression ‘stimulated emission of social information excitations’ might be misleading. One needs not to imagine stimulation as the process of consciously designed stimulation of a human population (after approaching the population inversion state) by a coherent flow of excitations. In physics lasers are merely known as artificially designed devices. However, nature creates lasers by itself without the conscious design of physicists. ‘Natural lasers’ are well known in astronomy¹⁰. In a same way, human (and other biological) societies are able to create ‘natural social lasers’, i.e., ASE self-generated by human societies. It seems that the majority of ASE during the last years are of a natural origin. The modern information societies can produce ‘natural social lasers’ as the result of the creation of extremely powerful communication channels, especially the Internet. We have already discussed the role of the mass media and the Internet in the discrete structuring of the social energy. They also produce periodically strong information pulses pumping social energy into the population. Such pumping excites extended layers of the population and leads to population inversion. Even the stimulated emission of social information excitations need not be planned and designed consciously. Coherent news (flows of identical social information excitations) can be produced without conscious design, simply as the result of the homogeneity of information flows delivered by the mass-media and the Internet.

We point out that one of the surprising features of the recent social protests and revolutions, is the absence of well formulated political programs and strong political leaders, see I. Krastev [5]. This feature

¹⁰The first ‘natural’ laser in space was detected by scientists on board NASA’s Kuiper Airborne Observatory as they trained the aircraft’s infrared telescope on a young, very hot, luminous star in the constellation Cygnus, see www.nasa.gov/home/hqnews/1995/95-148.txt

was widely and controversially debated in political studies, but without coming to a consensus on its meaning and origin. However, it matches well with the functioning of natural social lasers. Here, if a social group approached the state of population inversion, then any coherent flow of news of the energy matching with the energy level structure of this group can generate ASE. There is no need in writing say the ‘Manifesto of the Communist Party’ (issued by Marx in 1848); modern ASE happens without such figures as Martin Luther, Karl Marx, Vladimir Lenin,... In any event if the hypothesis that the modern information society can self-generate ASE is correct, then in the future one can expect the increase of the frequency of ASEs throughout the world - simply as one of the natural features of the modern information society¹¹.

Finally, when considering the possibility of the application of ASE to model social protests we make the following remark. Population inversion means that more than half of the population is excited. In fact, the real actions emanating out of protests involve a minority of population. Here it is important to distinguish the emission of a coherent wave of *s*-photons and the realization of their energy in real social actions. ASE (as well as stimulated emission of energy in physics) describes only the emission of the quanta of energy. The real social actions can be treated as analogs of the measurements performed on photons, i.e. the interaction of the field-quanta with atoms. In our social laser model, the majority of the population emits coherent *s*-photons, but only a fraction of them is ‘detected’, e.g. in clashes with police and army. However, the presence of a strong coherent wave of opposition plays a crucial role, at least in the aforementioned recent social protests and revolutions. In fact, the presence of such an information wave restricts the force of reactions from governmental organs.

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¹¹At the same time, we understand that the connection of recent social processes with a ‘natural social laser’ can be an illusion. If some powerful mechanisms can arise in a natural way, then very clever people will use and optimize them. We repeat that the analysis and interpretation of these events in the social and political literature are very controversial [1]–[5]. There are claims that the absence of political programs and strong political leaders is an illusion; these programs and leaders are just hidden.

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